REMARKS/ARGUMENTS

Reexamination and reconsideration of this application as amended is requested. By this amendment, claims 1, 3, 11, and 18 have been amended and claims 4, 9, and 17 have been cancelled. Claims 1, 3, 5-8, 10-11, 13-16, 18, 20, and 21 remain in the application.

REJECTION OF CLAIMS 1, 3, 5-8, 10-11, 13-16, 18, 20, AND 21 UNDER 35 U.S.C. §102

Claims 1, 3, 5-8, 10-11, 13-16, 18, 20, and 21 have been rejected under 35 U.S.C. 102 as being anticipated by Furuya et al.

The present invention comprises a small, compact, highly integrated fuel processor fabricated using multilayer ceramic technology into a single monolithic three-dimensional unit.

The basic components of all fuel processors are essentially similar and typically include a fuel vaporizer or evaporator, fuel reformer (e.g., steam reformer), combustor to provide heat for the steam reforming reaction, and optionally a preferential oxidation reactor to remove carbon monoxide. However, within the fuel processor of the present invention, these various discrete components described above are arranged to achieve fuel reforming in a small compact unit with high efficiency for portable power applications. This requires careful arrangement of these discrete components for thermally integration, fewer or no external tube connections between the various discrete components of the fuel processor for allowing the passage of reactants and product gas flows, and a gas tight sealed packaging to prevent leakage of explosive hydrogen (H_2) and toxic carbon monoxide (CO) gases to the external environment and prevent the outside atmosphere from leakage into the reactor to change the reaction equilibrium or degrade the catalyst.

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The present invention accomplishes these requirements in a small compact unit for portable power application by using multilayer ceramic technology. The required features of the various discrete components (vaporizer, reformer, combustor etc. in the fuel reformer unit) required for the final unit are fabricated as a single integrated design on individual ceramic sheets in the green state (unsintered), laminated to maintain the structural integrity, and sintered to form a monolithic ceramic unit. Communication between the various integrated components can be achieved by forming the required channels in the green state. This results in simple, gas tight connections between the integrated components, such that the only externally required connections would be liquid fuel inlet connected to the fuel tank and gas output connection to the fuel cell. Since the three dimensional, integrated arrangement of the vaporizer, reformer and combustor are close to each other (usually separated by a single layer of ceramic of 10-250 um thick), good thermal integration results. Inherent design of the fuel processor and the fabrication method accomplishes the task of integrating fuel processor components with thermal integration without any added complexity.

For example, the present invention when comprising a 35x15x5mm unit can produce sufficient hydrogen (from liquid methanol/water input) suitable for a 1 Watt size fuel cell, with only the fuel input and gas out external connections, which is ideally suited for portable power application. This compact design minimizes the total surface area (requiring minimum insulation around the reactor) and minimizes the losses into the surrounding through the reactor, thereby maximizing the fuel efficiency for portable power applications.

In the fuel processor of the present invention, the liquid fuel needs to be vaporized before transferring to the reformer section. In bigger, previously known units such as in Furuya, this is usually accomplished in a separate unit, typically called a heat exchanger, and the vapors

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are fed to the steam reforming section. For convenience, in the smaller potable unit of the present invention, liquid methanol/water mixture is transferred as a fuel to the fuel processor to generate hydrogen gas. Vaporization is a process where energy is required to change the physical property of a material from the liquid state to the vapor state. The energy required depends on the chemical nature of the material and the pressure and volume restrictions. The change in state from liquid to vapor is accomplished through a change in volume as energy is absorbed. If the volume is restricted during the change in state, a pressure is exerted on the container walls. The volume required by the material for the expansion with no changes in pressure depends on the amount of material going through the change of state. For a flowing case, the energy input or energy flux at a point needs to be constant for the amount of material passing by that point. Thus, a specific energy flux across a large surface area of material will result in a large volumetric expansion of that material. If the energy flux is insufficient, an energy drop will occur and a new volumetric expansion will result. This behavior is observed as "pulsing", and results in pressure and vapor flow changes in volumetrically restricted structures. Proper design of the vaporizer reduces or eliminates the "pulsing" behavior. In discrete components (the known art), long, gradual temperature gradients or large volume containers or buffers are employed, and are difficult to implement in a miniature fuel processor. The present invention utilizes the generated thermal gradient of the ceramic material and its internal 3 dimensional fluidic connectivity which provides for air gaps and minimizes liquid fuel surface area for expansion. This was accomplished with ceramic design features of a serpentine channel and multiple parallel micro-channels which act as a "sparger", to minimize the cross sectional surface area of the liquid for vaporization.

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The process used in the present invention needs to be controlled properly through the design and integration of the vaporizer in the fuel processor unit. As soon as the liquid is fed into the fuel processor, it will vaporize immediately causing a big volume expansion. This could cause pulsing and the gases would shoot through the reforming section before it has a chance to react properly over the catalyst bed to generate hydrogen and carbon dioxide. In this process, sometimes liquid droplets can also be carried away to the catalyst bed destroying the catalyst bed. In the present invention, this vaporization process is controlled by placing the vaporizer in a relatively cooler section, so the liquids do not get over heated quickly and vaporize with a burst. Micro channels are positioned between the vaporizer and the reforming sections to carry the vapors from the vaporizer section into the reforming section.

The cited Furuya patent reference describes a separate component to feed the "reforming machine" (see Figure 9 and 15, piping 46 and heater 47, for their "inherently comprising a vaporization zone"). In Example 1, fluid passages 3 and 4 are not initially at 200 degrees C at start-up; therefore, no vaporization can take place in the "reforming machine". To accomplish the combustion process, elements 46 and 47 were described in the text for Figure 9 and 15, and this is a discrete component. Additionally, "poured" as mentioned by the Examiner, is a translation interpretation of the original Japanese, and probably should be translated as "flowed". In paragraph [034], line 23, fluid appears to be defined as "hydrogen gas", and therefore could be interpreted as "gas" throughout, since "liquid", "liquid methanol", or "liquid methanol/water" was not ever used. "Fuel Supply" in [040] for the description of figure 8 description can again be interpreted as "gas fuel supply" and not liquid because of the "temperature change" of the "shape memory alloy".

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"In order to anticipate, prior disclosure must contain all the elements, or their mechanical equivalents, in the same description, method or device combined in substantially the same way to product substantially the same result as that accomplished by disclosure of patent in suit." McLemore v. Southern Impliment Mfg. Co., Inc., DC, ND Miss. 141 USPQ 7 (1964).

"For anticipation by prior art, each claim must be embodied in a single prior art reference, which must contain adequate directions for practice of the claim; additionally, elements must perform substantially the same function in substantially the same way to achieve substantially the same result in prior art and the claimed invention. Antici V. KBH Corp., DC, ND Miss., 168 USPQ 745 (1971).

More specifically, independent claims 1, 11, and 18 claim "the inlet channel, the vaporization zone, the reaction zone, the at least one vapor channel, and the outlet channel all comprising a fuel processor and all formed within an integral, sintered, monolithic ceramic carrier".

The cited Furuya et al. cited patent reference does not show, or suggest, a fuel processor wherein the inlet channel, the vaporization zone, the reaction zone, the at least one vapor channel, and the outlet channel all comprising a fuel processor and all formed within an integral, sintered, monolithic ceramic carrier as now included in the amended independent claims 1, 11, and 18. Furuya et al. teaches a descrete vaporizer, which lacks the advantages of a completely integral, sintered, monolithic ceramic fuel processor as claimed by the present invention and described above in detail.

Claims 3, 5-8, 10, 13-16, and 20 are believed allowable at least since they depend from what is believed to be an allowable claim.

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Accordingly, it is believed that the rejection of claims 1, 3, 5-8, 10-11, 13-16, 18, 20, and 21 under 35 U.S.C. 102 has been overcome by the amendment and remarks.

REJECTION OF CLAIMS 4, 9, AND 17 UNDER 35 U.S.C. §103

Claims 4, 9, and 17 have been rejected under 35 U.S.C. 103 as being unpatentable over Furuya et al. in view of Ghosh et al.

Claims 4, 9, and 17 have been cancelled.

CONCLUSION

The remaining cited references have been reviewed and are not believed to affect the patentability of the claims as amended.

No amendment made herein was related to the statutory requirements of patentability unless expressly stated; and no amendment made herein was for the purpose of narrowing the scope of any claim, unless Applicant has argued herein that such amendment was made to distinguish over a particular reference or combination of references.

In view of Applicant's amendments and remarks, it is respectfully submitted that Examiner's rejections have been overcome. Accordingly, Applicants respectfully submit that the application, as amended, is now in condition for allowance, and such allowance is therefore earnestly requested. Should the Examiner have any questions or wish to further discuss this application, Applicants request that the Examiner contact the Applicants attorneys at 480-385-5060.

If for some reason Applicants have not requested a sufficient extension and/or have not paid a sufficient fee for this response and/or for the extension necessary to prevent abandonment

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on this application, please consider this as a request for an extension for the required time period and/or authorization to charge Deposit Account No. 502,091 for any fee which may be due.

Respectfully submitted,

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